Gordon McKay Laboratory
Harvard University
Cambridge, Massachusetts 02138

Semi-Annual Status Report on

Grant NGR 22-007-056

Theoretical and Experimental Investigations of Antennas and Waves in Plasma

For the period

March 1, 1970 through August 31, 1970

September 1, 1970

Prepared for
Grants and Research Contracts Division
Office of Space Science and Applications
National Aeronautics and Space Administration
Washington, D. C. 20546

Linear Antennas in Lossy Media. L. D. Scott

Work is continuing on single antennas, insulated linear antennas, and coupled antennas immersed in homogeneous isotropic media. Experimental verification of the PEP theory as applied to antennas immersed in cool, collision-dominated laboratory plasmas is being planned. The equipment design to measure the current and charge distributions for bare antennas in the plasma is in progress.

Equipment has been designed and constructed to measure the electrical properties of linear insulated antennas with varying electrical lengths, insulation diameters, insulation dielectric constants, in various effectively infinite lossy media. Preliminary investigations are in progress.

The PEP method of solution has been used to calculate the self and mutual impedance for pairs of dipoles in air and compared with available measured data with excellent agreement. Further theoretical calculations for coupled dipoles in lossy media are in progress.

Experimental investigations are in progress for two coupled monopoles immersed in effectively infinite lossy media having a range of electrical lengths of $\beta h \leq \pi$ with spacings $\beta d \leq \pi$ in media for $\alpha/\beta < 1$. Field measurements on these antennas have been completed and the data are currently being reduced.

Theoretical and Experimental Studies on an Antenna in a Magnetoplasma. Bharathi Bhat.

The experimental investigation of the impedance behavior of a short cylindrical antenna in a lossy magnetoplasma is near completion. A new discharge tube has been designed and fabricated which incorporates an extremely durable directly heated cathode as well as an auxiliary anode. Frequency measurement techniques have been refined. A small, efficient, programmable calculator is used during the course of experimentation so that measured data can be reduced and plotted immediately. This approach eliminates some uncertainty and affords the experimenter the opportunity

of more closely investigating any interesting phenomena or anomalies. The theoretical portion of this investigation is concerned with the formulation and numerical solution of an integral equation for the distribution of current on an infinite tubular antenna immersed in a magnetoplasma. The practical applications of this study include the use of the short cylindrical antenna as an r.f. probe for determining electron density and collision frequency in the ionosphere.

Antennas in Isotropic Plasmas. D. H. Preis.

Considerable effort is required on all realistic aspects of the condition at the boundary between a source and a plasma and it is clear that the application of accurate sheath conditions to source problems has barely been attempted. It is necessary to obtain a better approximation to the physics of the antenna-plasma interface. A review of the previous work as well as new research into this area is underway. The actual boundary conditions to be used may have to be inferred through experimental measurements. Future measurements of admittance and current distributions of bare antennas in isotropic plasmas may provide valuable insights.

The Finite Cylindrical Antenna in a Warm, Isotropic Plasma. M. Vlachos.

Presently the research effort in this area is concerned with the finite cylindrical antenna (i.e., both finite length and radius) and particular emphasis is being placed upon those plasma phenomena which determine its driving-point admittance and distribution of current. It was decided to include electron-neutral collisions in the kinetic theory plasma model (even though this does considerably complicate the mathematics) because the resulting theory may be more readily compared to previous theories and experiments and it will be more useful to those concerned with r.f. plasma diagnostics. The electrically short cylindrical antenna is currently under investigation and theoretical results will be compared

to other theoretical and experimental work. It is expected that this investigation will be extended to include longer antennas.

A Short Cylindrical Antenna as a Diagnostic Probe for Measuring Collision Frequencies in a Collision-Dominated, Non-Maxwellian Plasma. L. D. Scott and B. Rama Rao.

At the Fall 1970 IEEE/URSI Symposium on Electromagnetic Theory held at Columbus, Ohio on September 14-17, 1970 Drs. Larry D. Scott and B. Rama Rao received the award for the best paper of the year for their paper "A Short Cylindrical Antenna as a Diagnostic Probe for Measuring Collision Frequencies in a Collision-Dominated, Non-Maxwellian Plasma" (IEEE Transactions, AP-17, 777, November 1969) which reported on work supported by this Grant.

The staff now supported in part by this grant includes two post-doctoral research fellows, Drs. L. D. Scott and D. H. Preis, and two part-time students, Miss Bharathi M. Bhat and Mr. Michael Vlachos.

The unexpended balance remaining to the credit of this grant as of August 31, 1970 was $6,204.59.

Submitted by,

Ronold W. P. King

Ronold W. P. King, Director
NASA Grant NGR 22-007-056